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THESIS

RELATIVE IMPORTANCE AND FREQUENCY OF USE OF 730 TOPICS WHICH MIGHT BE INCLUDED IN A PRACTICAL COURSE IN HIGH SCHOOL CHEMISTRY

Submitted by

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In partial fulfillment of requirements for
the degree of Master of Education

1936

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CHAPTER I

THE PROBLEM AND METHOD USED TO SOLVE IT

Importance and Need for Solution of Problem

Contributions of chemistry to everyday life.--Chemistry is one of the fundamental sciences since it deals with matter and its transformations. The structure of all of the material things of this world is explained by this branch of science. Great contributions have been made by the chemists to the health, safety and happiness of society, and to the agricultural and industrial progress of all nations.

Our food and water supplies, which we use without much thought as to the serious consequences should they contain certain impurities, are made comparatively safe for us by the work of the chemists.

Many of the devices which we use in our homes are made possible by, or owe their effectiveness to, the chemists who found or made the substances of which they are composed.

People earn their living in various occupations which owe their success, and in some cases their very existence to the chemists.

The iron and steel industry, which is the foundation of all industrial progress, has been able to improve its

old products, and to create new ones with entirely different properties through the advance of chemical knowledge.

The automobile industry would never have reached its present status if chemists had not found suitable steels and alloys for the various parts of the machine, non-shattering glass for greater safety, gasoline for power, oils for the protection of the moving parts, and lacquers to beautify the exterior.

The textile and paper pulp industries would be crippled if they were to be deprived of the numerous bleaching substances and dyestuffs so necessary in the making of paper and clothing.

The transportation facilities of the world would be far behind their present stage of development had the chemist neglected them. They demanded and received suitable liquid fuels for power, and refrigeration plants to preserve food. The values of air conditioning were revealed by determining the components of air and their effects on the human body. Light but strong metals were provided for lighter than air craft and the dangerous hydrogen gas for dirigibles and balloons was replaced with the non-inflammable helium.

These are only a few of the innumerable examples which might be given to show the important relation of chemistry

to our everyday life. Chemistry should not be given the entire credit for such achievements but it can be given a large share in conjunction with the other sciences.

Need for a knowledge of chemistry.--A little reflection about the above facts should reveal that all citizens need some knowledge of chemistry.

A graduate of our high schools is expected to have some accurate knowledge of his surroundings. Certainly a course in chemistry would aid in making this a reality.

Many of these people will select occupations of such nature that a knowledge of this subject would be a decided asset to them in their work.

They will also read and hear of many things which would be better understood by them if such facts were a part of their education.

Some deficiencies of chemistry teaching.--Our high schools today present a highly technical and mathematical course in chemistry to prepare a certain small group for college, and a more intensive study in this field.

However, we have another much larger group of students who are not going to college, but who will, in all probability, become homemakers and workers in the agricultural and industrial occupations. Some of these people are of lower intelligence and are "scared away" from

the course described above because of the very real danger that they cannot "pass" it. The others of higher intelligence do not consider it because it will have little practical value for them in their future life.

It seems obvious that we should provide a simpler, more practical course in chemistry for this second group of students who do not go on to college. Most of our high schools have disregarded this need and continue to offer the traditional course. Some of the more progressive schools are presenting a second more practical treatment of chemistry for these pupils. However, the content of these practical courses is almost as varied as the number of schools presenting them. This may be accounted for by the fact that the teachers of chemistry do not agree as to what should be taught to these pupils. This is proven very well by a comparison of the ratings which different chemistry teachers gave to the same topic on the rating-lists. These rating-lists will be more fully explained later. This same difference of opinion was made quite apparent to the writer during interviews with most of the chemistry teachers who later submitted rating-lists.

Very few text books have been written which are suitable for this type of a course. Those which have are for the most part simpler treatments of the subject matter of the conventional college preparatory texts. No attempt

has been made to include topics of greater everyday value. Where such an attempt has been made the topics have been selected by the author according to his own personal ideas as to what will be of service to the pupil. Such topics may or may not meet the immediate and future needs of these people.

Problem to be solved.--Since such a variety of opinion exists as to what should be taught in such a course, the service-problem arises; "Which of the facts, which might be included in a simpler, more practical course in chemistry, will have the greatest value and the largest number of applications in the daily life of the average person?"

Techniques Employed to Solve Problem

Selection of topics.--The first step in seeking an answer to this question was the preparation of a list of the facts or topics now being taught in high-school chemistry courses and other topics which might be included in a course such as that just described.

This list was selected from the following sources:

1. Chemistry textbooks now being used in our high schools.
2. Textbooks used for training in particular vocations such as nursing or textile manufacture.

3. Textbooks dealing with special phases of chemistry such as agriculture, dairying, cooking and sanitation.
4. Interviews with chemistry teachers.
5. Books on chemistry written for laymen.

A list of the books which were of greatest value in the preparation of this rating-list will be found on page 62 of the appendix.

Method of rating topics.--The 730 topics were selected from these sources and were arranged in thirteen groups suitable for rating by qualified judges selected for this purpose. Each topic was rated by these judges on two bases:

1. How important is it for the average person to know this fact?
2. How frequently will he find use for it in his daily life?

In making the first rating, that is, in indicating the importance of the item, "5" was used to indicate very great importance; "3" to indicate average importance; and "1" to indicate little or no importance.

In making the second rating, that is in indicating the frequency of occurrence, "5" was used to indicate very frequent use; "3" to indicate occasional use; and "1" to indicate that it would be used seldom or not at all.

Selection of raters.--Sixty judges were selected and divided into two groups. One of these, which will hereafter be referred to as "group 1" consists of thirty-six persons trained in the field of chemistry, and the other which will be designated as "group 2" made up of people without previous training in chemistry.

The opinion of this second group of raters does not lack significance because of the fact that they have had no previous training in this field. Rather it is of considerable importance since they should know better than anyone else the facts of chemistry which they have had to learn through experience, and also those which would be of some importance to them, if they knew something about them.

Table 1 indicates the vocations engaged in by the thirty-six raters who have training in chemistry.

Table 1. Vocations of Raters in Group 1.

Vocation	Number
(1)	(2)
Teachers of chemistry----------	18
Teachers of other sciences-----	6
Industrial chemists----------	3
Former teachers of chemistry now in executive positions---	3
College professors----------	2
Pharmacists----------	2
Structural engineer----------	1
Heat engineer----------	1
Total	36

Table 2 indicates the vocations engaged in by the twenty-four raters who have no formal training in chemistry.

Table 2. Vocations of Raters in Group 2.

Vocation	Number
(1)	(2)
Post-office employees	3
Office executives	3
Mill superintendents	2
Shoe-factory superintendents	2
Machine-shop foremen	2
Teachers	2
Students	2
Automobile dealer	1
Undertaker	1
Radio-repair man	1
Rubber-factory employee	1
Town official	1
Plumber	1
Newspaper editor	1
Food-store manager	1
Total	24

Computation of averages.--After the judges had rated their respective lists of 730 topics as directed, the average ratings for "importance of knowing", and "frequency of use" was computed for each topic. The simple average or mean was found in each case, by dividing the total number of points given to the topic by the number of times it was rated.

The ratings given to the topics by the two groups of judges were kept separate for purposes of comparison.

CHAPTER II

RESULTS OF THE STUDY

In Table 3 beginning on page 15 will be found the topics submitted to the judges for rating, and the averages computed from their ratings.

The topics are arranged in thirteen groups similar to those on the original rating-lists sent to the judges. The topics within the groups, however, have been rearranged so that they are in descending order according to the average rating on "importance of knowing" as determined by group 1, or, the group of judges trained in chemistry. The average ratings of each topic for "frequency of use" by group 1, and for "importance of knowing" and "frequency of use" as judged by group 2, will be found in the other vertical columns of the table under the appropriate headings.

The mean rating on "importance of knowing" the topic was found to be 3.2 for group 1 and 3.0 for group 2. It is interesting to notice the close relation of these two averages when we consider that the group of laymen have no training in chemistry.

The mean rating for "frequency of use" as determined for group 1 is 2.4 and for group 2 it was found to be 2.2.

Figure 1, shown below, indicates the distribution of the average ratings given to the 730 topics on the basis of "importance of knowing" them in daily life, by the group of chemistry teachers and chemists referred to as group 1. It

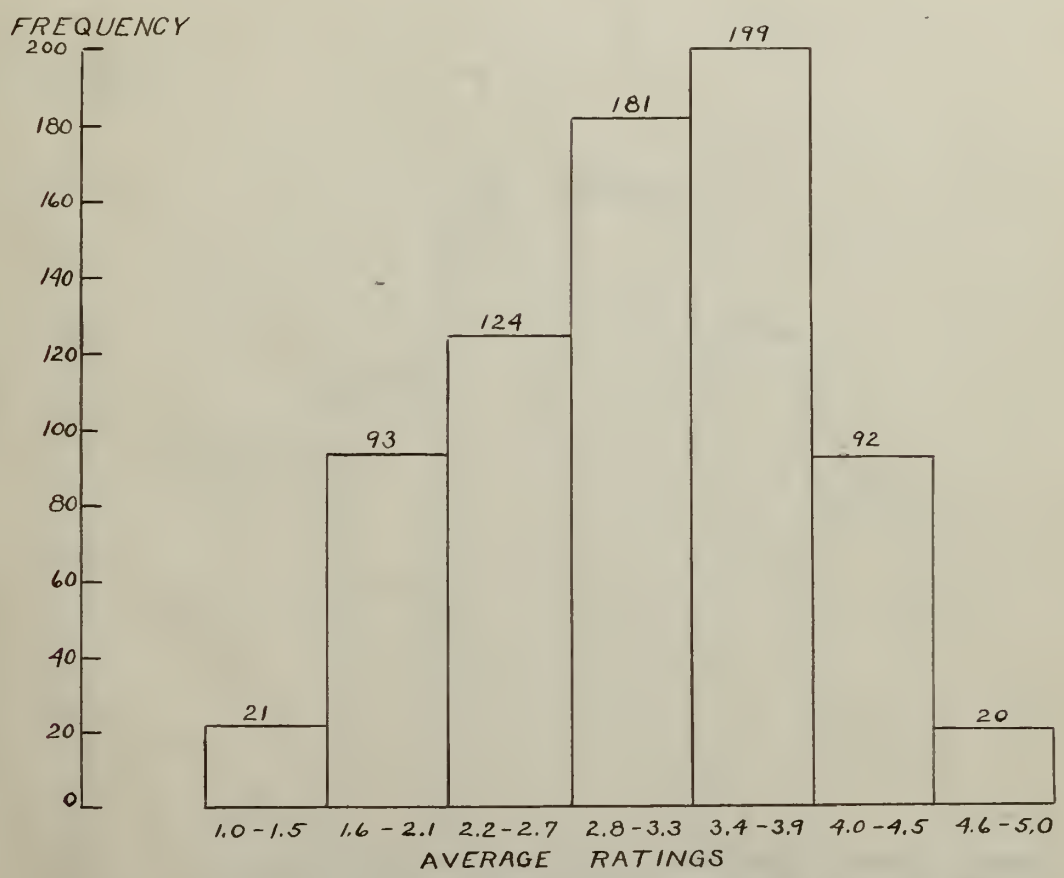

Figure 1. Distribution of Average Ratings Assigned 730 Chemistry Topics by a Group of Chemistry Teachers and Chemists on the Basis of Importance of Knowing for Daily Life.

is a somewhat uneven distribution of the average ratings giving a mean higher than might be expected. We shall give some possible reasons for this condition in the pages which follow.

In Figure 2 is shown the distribution of average ratings given to the topics on the same basis by the group of laymen who have had no formal training in chemistry. The curve is quite even when we consider that these people must

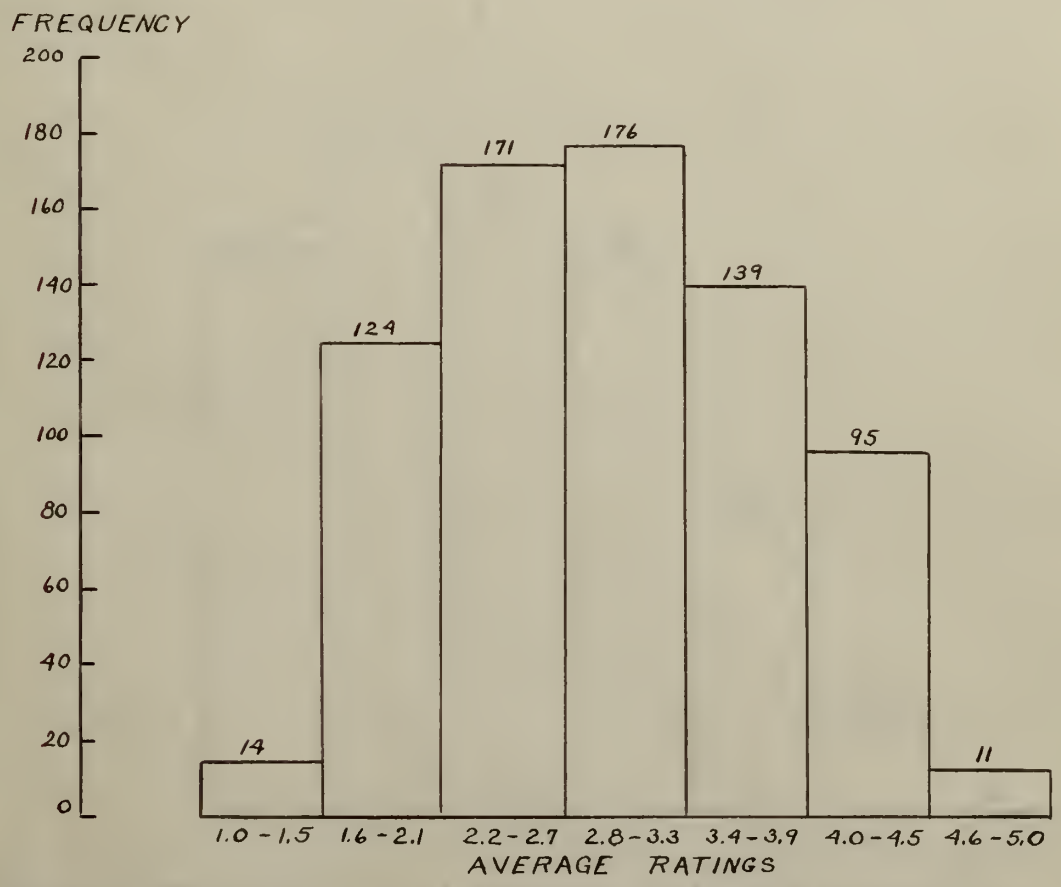

Figure 2. Distribution of Average Ratings Given 730 Chemistry Topics by a Group of Laymen on the Basis of Importance of Knowing in Daily Life.

have experienced some difficulty in interpreting many of the topics which were listed.

Figure 3 indicates the very uneven distribution of the average ratings assigned to the various topics by the

chemistry teachers and chemists, on a basis of the frequency with which they will be used in daily life. A large proportion of the topics were rated below average in this respect. The average ratings on this same basis

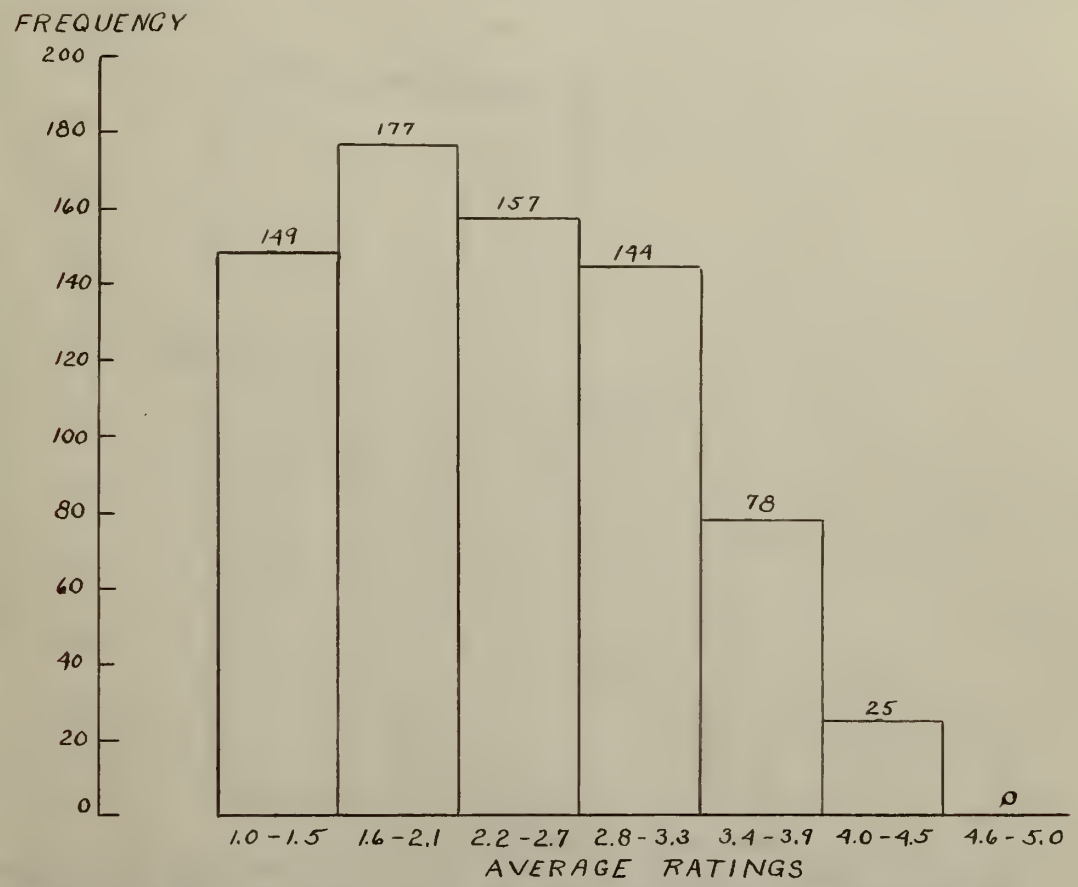

Figure 3. Distribution of Average Ratings Assigned 730 Chemistry Topics by Chemistry Teachers and Chemists on the Basis of Frequency of Use in Daily Life.

assigned by the group of laymen show this same marked tendency. This can be seen by a study of Figure 4.

This condition may be explained in several ways:

1. The laymen did not realize the large number of

applications which many of the topics have, in daily life, due to his lack of knowledge of this subject.

2. There was a tendency on the part of the laymen

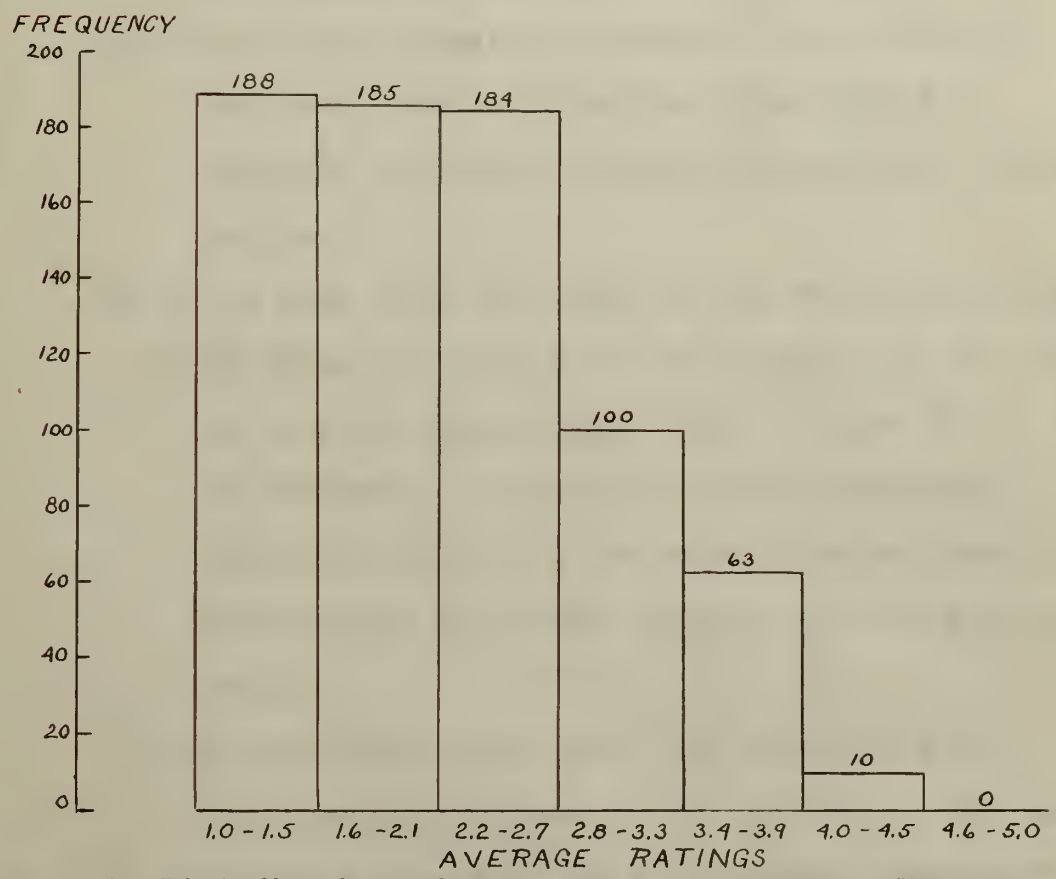

Figure 4. Distribution of Average Ratings Given 730 Chemistry Topics by a Group of Laymen on the Basis of Frequency of Use in Daily Life.

to rate the topics on a basis of what they themselves would use in their particular occupation rather than to consider other occupations as well as their own. This fact

was brought out in later conversations with these people. Those who tried to consider people in other walks of life may have been handicapped by a lack of knowledge of the requirements for other kinds of work.

3. Fifty-three per cent of group 1 are chemistry teachers, some of whom may have failed to consider fully all of the applications of some topics.

4. It is also true that many of the facts which are of vital importance for us to know are not used by us very frequently. This is true of the facts of arithmetic, English and other subjects. Perhaps, therefore, the mean obtained here is nearer what it should be than one would at first expect.

5. There may also have been some difference of interpretation given by the raters to the terms, "very frequently" and "of average frequency" which were used in the directions on the rating-list.

A study of Table 3 will reveal the results of this research much better than words can describe them. This table will be found on the following pages.

Table 3

AVERAGE RATINGS ASSIGNED 730 CHEMISTRY TOPICS BY A GROUP OF CHEMISTRY TEACHERS AND CHEMISTS, AND BY A GROUP OF COMPETENT LAYMEN, FROM THE STANDPOINT OF IMPORTANCE AND FREQUENCY OF USE IN DAILY LIFE

TOPICS AND SUB-TOPICS	Ratings of Group 1*		Ratings of Group 2*	
	I**	F**	I**	F**
AN INTRODUCTION TO CHEMISTRY				
A. History				
1. Discovery of oxygen, or the work of Priestly and Lavoisier.	3.8	2.6	3.7	2.2
2. Man's early knowledge of, and use of, metals.	2.4	1.4	2.3	1.5
3. Discoveries and additions to knowledge by alchemists.	2.2	1.5	2.5	1.7
4. The phlogiston theory of burning.	2.2	1.4	1.7	1.2
5. The "elements" of the Greeks.	1.9	1.4	1.6	1.2
6. The theory of transmutation of metals.	1.8	1.2	2.0	1.3
7. Ideas of the alchemist of the Middle Ages.	1.8	1.6	1.7	1.2
8. Belief in a "philosopher's stone".	1.6	1.1	1.3	1.1
B. Meaning and Importance of Chemistry				
1. What chemistry deals with.	4.4	3.5	4.1	3.0
2. Meaning of, and steps involved in, an experiment.	4.3	3.4	3.6	2.7
3. Values in study of chemistry.	4.2	3.3	3.6	2.9
4. Opportunities for chemists in various vocations.	4.0	3.2	4.1	3.2

* Group 1 is composed of chemistry teachers and chemists.
Group 2 is composed of competent laymen.
** I means "importance of knowing".
F means "frequency of use in daily life".

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
B. Meaning and Importance of Chemistry (continued)				
5. Diagrams, or the chemists' way of picturing things in the simplest and clearest way.	3.9	2.5	3.7	2.8
6. Relation of chemistry to the other sciences.	3.8	3.1	3.7	2.7
7. Meaning of fact, hypothesis, theory and law, and how they are developed.	3.8	3.1	2.8	2.2
8. How the chemist solves his problems by inductive and deductive thinking.	3.7	3.1	3.3	2.1
C. The Chemists' View of Matter				
1. Distinction between the kinds of substances, such as, elements, compounds, mixtures, and impurities.	4.4	3.1	3.7	2.7
2. Difference between physical and chemical changes.	4.3	3.1	3.6	2.7
3. Agents which aid chemical change, such as, heat, pressure, electricity, light, catalysts and enzymes.	4.3	3.6	4.0	3.5
4. Kinds and states of matter and energy.	3.7	3.4	2.8	2.3
5. Physical and chemical properties distinguished.	3.7	2.5	3.2	2.3
6. The chemists' shorthand (symbols and formulas).	3.7	2.6	3.0	2.5
7. Measurement of matter (the metric system of length, weight, and volume).	3.7	2.8	3.1	2.4
8. Matter and energy distinguished.	3.6	2.3	2.8	2.4
9. Scales of temperature in common use including absolute scale.	3.6	2.6	2.9	2.7
10. Meaning and use of the term, specific gravity.	3.6	2.6	3.5	2.6
11. Types of chemical changes, and how to distinguish between them.	3.5	2.3	2.6	1.8
12. Construction of thermometer.	3.5	2.3	2.6	1.7
13. Relation of energy to chemical change.	3.1	2.4	2.2	1.8

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
I COMMON GASES				
A. General Properties				
1. Weight and pressure, and their relation to the barometer, siphons, pumps, boiling point of liquids.	3.7	3.1	3.8	3.1
2. Application of the above principle in ventilation of buildings, ships, and mines.	3.7	3.3	3.6	2.7
3. Expansion and contraction of gases with temperature change.	3.6	2.8	3.2	2.1
4. Use of sulphur dioxide, ammonia, carbon dioxide and methyl chloride as refrigerants.	3.6	2.8	3.1	2.1
5. How the behavior of gases affects the weather.	3.2	2.6	2.7	1.7
6. How the pressure cooker works.	3.1	2.8	2.7	2.1
7. Elasticity and compressibility and their application to air brakes and pneumatic riveters.	3.1	2.6	3.0	2.4
8. Meaning and use of the term, "standard conditions".	2.9	1.8	2.9	2.5
9. Temperature of gases due to their expansion or compression.	2.8	2.1	2.2	1.7
10. Critical temperature and pressure, and their importance in fractional distillation.	2.1	1.3	1.6	1.3
11. Effect of vapor pressure of liquids on apparent pressure.	1.9	1.3	1.7	1.4
12. Use of gases in special types of thermometers.	1.7	1.1	1.4	1.2
B. Air				
1. Its relation to life and burning process.	4.8	4.2	4.2	3.4
2. Composition.	4.5	3.4	4.0	2.6

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
B. Air (continued)				
3. Meaning and relation of relative humidity to physical comfort and rainfall.	4.4	3.5	3.6	2.7
4. The air as a carrier of disease germs and bacteria.	4.2	3.8	4.4	3.6
5. Amount required and proper size of ventilators.	3.9	3.1	3.8	3.0
6. Methods of air conditioning.	3.7	3.1	3.6	2.7
7. The smoke menace and what can be done to eliminate it.	3.6	2.9	3.3	2.9
8. Losses and dangers due to the presence of dust in air.	3.5	3.2	3.6	2.7
9. Use of liquid air on altitude flights and in the making of nitrogen and oxygen.	2.1	1.6	2.2	1.5
10. Manufacture and properties of liquid air.	1.9	1.2	2.0	1.4
C. Hydrogen				
1. Occurrence in water, acids, and hydrocarbons.	3.6	2.4	2.7	1.8
2. Properties.	3.6	2.2	2.7	1.7
3. Dangers involved in its use for balloons and dirigibles.	3.6	2.6	3.0	1.6
4. Hydrogenation process for producing solid fats suitable for cooking, and for making liquid fuels from coal.	3.0	2.1	2.2	1.7
5. Use as a reducing agent and stereopticon.	2.9	1.6	1.7	1.3
6. Atomic hydrogen flame and its use in welding.	2.9	1.9	2.9	2.1
7. Methods of preparation.	2.8	1.6	2.0	1.5
8. Future possibilities of hydrogenation.	2.7	1.8	2.1	1.3
D. Oxygen				
1. Process of oxidation applied to combustion, rusting of metals, decay of organic matter and digestion of food.	4.8	4.4	4.2	3.2
2. Meaning of spontaneous combustion, conditions necessary for, and how to prevent it.	4.8	4.0	4.6	3.6

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
D. Oxygen (continued)				
3. Occurrence and abundance.	4.4	3.5	3.2	2.6
4. Common properties.	4.3	3.6	3.1	2.5
5. Methods of preventing the rusting of iron.	4.2	3.8	3.9	3.1
6. Methods of preparation.	3.6	1.9	3.0	1.9
7. Use of oxygen in pulmotor and artificial respirators.	3.6	2.6	4.0	2.9
8. Hydrogen peroxide and its use as a bleaching agent and for medicinal purposes.	3.6	3.2	3.5	2.3
9. Substances commonly used as oxidizing and reduction agents.	3.4	2.3	2.0	1.4
10. Oxy-hydrogen and oxy-acetylene flames and their uses.	3.4	2.4	3.2	2.2
11. Reduction and its use in manufacture of pure metals.	3.2	1.9	2.2	1.2
12. Ozone and its use in purification of water and as a bleaching agent.	2.8	1.9	2.8	1.7
E. Carbon Dioxide				
1. Production in breathing, burning and decay.	4.5	3.7	3.4	2.7
2. Use in fire extinguishers.	4.3	3.7	3.9	2.7
3. How produced and why desirable in baking foods.	4.0	3.8	2.9	2.6
4. Carbon-oxygen cycle in nature.	3.8	2.7	2.7	1.9
5. How it is used in soda water and beverages.	3.8	3.5	3.2	2.2
6. Common properties.	3.7	2.9	3.2	2.0
7. Properties and dangers involved in handling dry ice.	3.7	3.1	3.7	2.6
8. Uses and advantages of this ice over ordinary ice.	3.4	2.7	2.9	2.2
9. Treatment required to convert it into dry ice.	3.1	2.1	2.3	1.7
10. How it will form carbonic acid which is responsible for formation of limestone caves.	2.4	1.4	1.9	1.2

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
F. Carbon Monoxide				
1. Properties and danger (poison).	4.9	4.4	4.9	3.4
2. How it is produced.	4.5	2.9	4.4	3.4
3. Use as a reducing agent.	2.2	1.3	1.8	1.6
G. Nitrogen				
1. Presence in air, soil, and foods.	4.3	3.4	3.7	3.1
2. Importance in fertilizer industry.	4.2	3.5	4.2	3.2
3. Importance as chief constituent of air.	3.8	2.4	3.3	2.2
4. Properties.	3.5	2.4	3.1	1.9
5. Use of hydrocyanic acid (poison) to destroy insect pests.	3.4	2.3	3.8	2.5
6. Use of nitrous oxide as an anesthetic and as tear gas.	3.2	2.4	2.8	1.7
7. Use of glyceryl nitrate, silver nitrate and argyrol as medicines.	3.2	2.3	3.0	2.1
8. Action in electric light bulbs.	2.7	2.4	2.7	1.7
H. Ammonia				
1. Use as a cleaner, and in aromatic spirits of ammonia.	3.7	3.2	3.5	2.9
2. Properties and its use in making household ammonia.	3.1	2.9	2.6	2.2
3. Formation in decay of vegetable matter.	2.8	2.1	2.5	2.1
4. How prepared from compounds.	2.8	1.7	2.8	2.1
I. Chlorine				
1. Table salt, a compound of chlorine.	4.3	3.7	3.6	3.1
2. Harmful effect on animal tissue (poison).	4.1	2.5	3.4	2.1

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
I. Chlorine (continued)				
3. Antidote for chlorine poisoning.	3.8	2.1	4.1	1.8
4. Use in bleaching and in treatment of colds.	3.7	3.1	3.3	2.2
5. Common properties.	3.6	2.4	2.7	1.8
6. Use as a stain remover.	3.3	2.6	3.1	2.7
7. How prepared from compounds.	2.8	1.7	2.0	1.5
8. Effects of poisonous gases and the amounts required.	2.6	1.7	2.8	1.7
9. Peacetime use of equipment for spreading gas.	2.4	1.7	2.3	1.7
10. Composition of poisonous gases used in warfare.	2.3	1.7	2.6	1.7
J. Helium, Argon, and Neon				
1. Use of argon and neon in light bulbs and lighted signs.	3.4	2.8	3.3	2.3
2. Use of helium for balloons and dirigibles.	3.3	2.4	2.9	1.7
II WATER				
1. Diseases caused by common impurities in water.	4.7	4.0	4.5	3.8
2. Causes of contamination and how to prevent it.	4.7	3.8	4.7	4.0
3. Methods of purifying water.	4.7	3.9	4.6	3.7
4. Impurities commonly found.	4.6	3.7	4.6	3.7
5. Sources of water supply.	4.4	3.7	4.4	3.8
6. Proper methods of sewage disposal.	4.4	3.5	4.7	3.6
7. Composition of water.	4.1	2.8	3.5	2.5
8. Occurrence.	3.9	3.4	3.2	2.6
9. Evaporation and condensation and their effect on temperature.	3.9	3.4	3.6	2.9
10. "Hard water" and what causes it.	3.9	2.9	3.6	2.7

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
II WATER (continued)				
11. Meaning of terms such as solute, solvent, solution, concentrated, dilute, saturated and supersaturated.	3.8	2.9	3.7	2.7
12. Substances used to "soften" hard water.	3.7	2.9	3.5	3.0
13. Great loss of soap in washing due to "hard water".	3.5	2.8	3.4	2.5
14. Heat capacity compared with other substances.	3.4	2.6	3.2	2.7
15. Why the surfaces of ponds and lakes freeze first.	3.4	2.5	3.0	2.1
16. Process of osmosis.	3.4	1.8	2.2	1.5
17. Effect of heat capacity of water on climate.	3.4	2.7	2.6	2.2
18. Distinction between solution, suspension, emulsion, and colloids.	3.2	2.5	3.1	1.9
19. Formation of, and losses due to formation of boiler scale.	3.1	2.4	2.8	2.2
20. Methods of determining "hardness" of water.	3.0	2.0	2.7	2.1
21. Electrolysis of water.	2.9	1.4	2.2	1.5
22. Heat of vaporization and fusion.	2.8	1.9	2.2	1.8
23. Early methods of obtaining and transporting water.	2.6	1.6	2.4	1.4
24. How crystals are produced.	2.5	1.3	2.1	1.5
25. Water of crystallization and common hydrates.	2.3	1.7	1.8	1.4
26. Distinction between crystalline and amorphous substances.	2.3	1.6	1.9	1.3
27. Structure of crystals.	2.2	1.2	2.2	1.5
28. Determination of volumetric and gravimetric composition by analysis and synthesis.	1.7	1.1	1.7	1.4
III FIRE-THE SERVANT AND ENEMY OF MAN				
1. Principles of extinguishing fires.	4.8	4.1	4.5	3.6
2. Common fire fighting chemicals and extinguishers and how to use them.	4.6	3.9	4.7	3.6

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
III FIRE THE SERVANT AND ENEMY OF MAN (continued)				
3. Requirements for combustion.	4.5	4.1	4.2	4.0
4. Causes of destructive fires.	4.4	3.7	3.7	3.1
5. Possible harmful gases liberated from fuels.	4.1	3.6	4.2	3.7
6. Heat values of common fuels compared with current prices.	3.9	3.5	4.1	3.7
7. Losses due to destructive fires.	3.9	3.3	3.2	3.1
8. Effects of heat on solids, liquids, and gases.	3.9	3.3	3.6	2.7
9. Essential constituents of fuels.	3.9	2.7	3.1	2.5
10. How to regulate flames and burners.	3.8	3.5	3.1	2.5
11. Explanation of mine explosions, and that of carburetor mixture of gases in automobile engine.	3.8	3.1	4.2	3.6
12. How matches are made and why they produce a flame.	3.8	3.2	3.6	2.4
13. Methods of transmission of heat.	3.8	3.3	3.5	2.8
14. How explosions are caused by increase of gas volumes.	3.7	2.4	3.9	2.6
15. Structure of flames.	3.6	2.9	2.7	2.2
16. How to buy coal on specification.	3.5	2.7	3.2	2.6
17. Nature of heat.	3.5	2.3	3.5	2.4
18. Chemistry of the burning candle.	3.3	2.2	2.9	1.7
19. Manufacture of liquid fuels such as kerosene, ether, and gasoline.	3.3	2.6	2.9	2.4
20. How heat is measured.	3.3	2.2	2.3	1.6
21. Occurrence or manufacture of gaseous fuels such as natural producer, coal and water gases.	3.2	2.7	3.1	2.5
22. Heat changes during condensation, vaporization, and in the freezing process.	3.2	2.4	2.8	2.5
23. Percentage of heat lost in chimney gases.	3.1	2.7	2.9	2.3
24. Formation of solid fuels such as peat and coal.	2.9	2.1	2.7	2.1

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
III FIRE-THE SERVANT AND ENEMY OF MAN (continued)				
25. Percentage of heat lost in unconsumed ash.	2.9	2.6	2.9	2.5
26. Limits of explosive mixtures.	2.8	1.9	3.4	2.1
27. Early history of fire and heating devices.	2.4	1.8	2.7	1.9
28. How to test for heat values with the calorimeter.	2.2	1.4	2.0	1.4
29. Absolute scale of temperature and its use in chemical work.	2.0	1.4	2.6	1.4
IX ACIDS BASES AND SALTS				
1. General properties of all common acids.	4.4	3.1	3.4	2.4
2. Treatment of acid burns.	4.3	3.2	4.7	2.9
3. Antidotes for acid poisoning.	4.1	3.0	4.6	2.7
4. Treatment of burns by alkali.	3.9	2.7	4.0	2.7
5. Uses of common inorganic acids.	3.8	2.9	3.3	2.7
6. Properties common to all bases.	3.8	2.6	2.9	2.0
7. Antidote for alkali poisoning.	3.8	2.6	3.8	2.3
8. How substances may be neutralized.	3.8	2.8	3.2	2.2
9. Methods of determining acidity with dyes such as litmus, and phenolphthalein.	3.7	2.3	3.0	2.1
10. Use of neutralization in cases of "acid soil".	3.5	2.8	3.5	2.4
11. Meaning of "strong" and "weak" acids.	3.4	2.4	3.1	2.3
12. Special properties of common inorganic acids.	3.4	2.2	2.7	1.9
13. Uses of common organic acids.	3.4	2.8	3.6	3.1
14. Occurrence of inorganic acids in foods and common products.	3.3	2.5	3.7	3.0
15. Use of neutralization process in treating insect bites.	3.2	2.4	3.1	2.4
16. General properties of all salts.	3.2	2.3	3.2	1.9

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
IX ACIDS BASES AND SALTS (continued)				
17. How acids may be formed.	3.1	1.9	2.9	2.0
18. How bases may be formed.	3.1	1.8	2.9	2.0
19. Use of neutralization in industrial processes to destroy excess acid or alkali substances.	3.1	2.0	2.8	1.8
20. How electrolytes conduct an electric current.	3.1	2.0	3.5	2.1
21. Method of naming acids and their respective salts.	2.8	2.0	2.4	1.6
22. Commercial preparation of common inorganic acids.	2.8	1.9	2.4	2.0
23. Concentration of solutions expressed in percent.	2.8	1.9	2.0	1.4
24. Laboratory preparation of common inorganic acids.	2.7	1.3	2.2	1.8
25. Distinction between base, alkali, and caustic alkali.	2.6	1.9	2.6	1.9
26. Methods of preparing salts.	2.6	1.8	2.7	1.7
27. Salts as a source of the elements which they contain.	2.6	1.8	2.2	1.8
28. Specific properties and derivatives of common organic acids.	2.5	1.9	2.7	2.0
29. Acid, basic and normal salts.	2.4	1.5	2.0	1.4
30. Factors which affect the degree of ionization.	2.3	1.1	2.0	1.3
31. Use of electrolytes in maintaining proper osmotic pressure of body fluids.	2.1	1.2	2.0	1.5
32. Hydrolysis and its relation to these salts.	2.0	1.3	2.1	1.6
33. Binary and ternary acids.	1.9	1.3	1.8	1.3
34. Classification according to number of replaceable hydrogen atoms.	1.9	1.3	1.8	1.3
35. Mono, di and tri hydroxyl bases.	1.8	1.1	1.6	1.3
36. Titration as a method of determining concentration of solutions.	1.8	1.2	1.7	1.3
37. Normal solutions and multiples of same.	1.7	1.2	2.0	1.3
38. Molar solutions and multiples of same.	1.7	1.2	2.0	1.4
39. Meaning of physiological normal solutions.	1.5	1.2	2.0	1.3

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
V NON-METALS AND THEIR COMPOUNDS				
1. Uses of sulphur for matches, fertilizers, fungicides, and in the paper pulp industry.	3.8	3.1	3.5	2.3
2. Salts of arsenous and arsenic acids used as insecticides and weed killers. (Poisons)	3.8	3.4	3.7	2.7
3. How ordinary glass is made.	3.5	2.7	3.1	1.6
4. Use of various phosphates in making fertilizers.	3.5	2.8	3.3	2.5
5. Components and method of making cement.	3.4	2.8	3.3	2.6
6. Distinction between metals, non-metals, and amphoteric elements.	3.3	2.2	3.2	2.0
7. Ammonium chloride (sal ammoniac) and its use in dry cells.	3.2	2.8	3.1	2.1
8. Carbon disulphide and its use to destroy insects and small animals.	3.1	2.4	2.7	2.4
9. Preparation of sulphurous acid and its use in bleaching straw, wool, and silk.	3.1	2.3	2.7	1.8
10. Use of potassium bromide as sedative in medicine.	3.1	2.5	2.7	1.7
11. Use of potassium chlorate in making explosives, matches, and fireworks.	3.0	2.6	2.7	1.9
12. Occurrence and forms of silicon dioxide or silica such as quartz, onyx, flint, opal, and amethyst.	2.9	2.1	2.1	1.7
13. Method of making optical, pyrex, and laboratory glass, and imitation gems.	2.9	2.1	2.7	1.8
14. Properties (especially poisonous one) of hydrogen sulphide	2.9	1.7	3.2	1.7
15. Preparation of chlorine and iodine.	2.9	1.6	2.5	1.3
16. Ethylene bromide and its use in "ethyl" gasolene.	2.9	2.7	2.8	2.1
17. The silicate minerals (garnet, mica, soapstone, asbestos, emerald, feldspar, and Kaolin), and their uses.	2.8	2.0	3.2	2.2
18. Process of making porcelain and china.	2.8	1.9	2.6	1.5

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
V NON-METALS AND THEIR COMPOUNDS (continued)				
19. Manufacture of sulphuric acid by contact and lead chamber processes.	2.8	1.3	1.7	1.3
20. Use of hydrofluoric acid to etch glass and to remove sand from castings.	2.8	1.7	2.5	1.6
21. Hypochlorous acid, the bleaching agent.	2.8	2.1	2.2	1.8
22. Properties of the oxides of nitrogen.	2.8	1.7	1.7	1.2
23. How silicon carbide is made and used as polishing and whetstones.	2.7	2.1	2.2	1.6
24. Methods of mining sulphur.	2.7	1.6	2.1	1.3
25. Phosphorus and its relation to phosphorescence and luminescence.	2.7	1.9	2.3	1.5
26. Occurrence and preparation of borax.	2.6	2.0	2.2	1.7
27. Methods of producing sulphur dioxide gas.	2.6	1.6	2.4	1.3
28. Why straw hats become yellow with age.	2.6	2.1	2.3	1.7
29. Test for sulphuric acid and sulphates.	2.6	1.5	2.5	1.6
30. Use of silica to make sandpaper.	2.6	2.4	2.7	1.9
31. Uses of fluorides as soldering fluxes, component of insect powders, and in enamels.	2.5	2.1	2.8	1.9
32. Manufacture of, and use of calcium carbide in making acetylene.	2.4	1.5	2.4	1.5
33. How borax serves as a soldering flux.	2.4	2.1	2.4	2.0
34. Use of potassium iodide to increase rate of absorption of blood clots.	2.4	1.6	2.7	1.6
35. Preparation and tests for nitrates.	2.4	1.4	1.9	1.2
36. How arsenic is detected. (Marsh and Gutzeit tests)	2.4	1.5	3.4	1.7
37. Properties of allotropic forms of sulphur.	2.3	1.6	1.8	1.4

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
V NON-METALS AND THEIR COMPOUNDS (continued)				
38. Preparation of hydrogen sulphide.	2.3	1.4	2.1	1.3
39. Use of hydrogen sulphide in analysis.	2.3	1.3	2.0	1.3
40. Tests for silver, lead, and mercurous compounds.	2.3	1.4	2.5	1.3
41. Preparation and oxidizing properties of the chlorates.	2.3	1.7	1.7	1.4
42. Use in medicine of antimony trichloride and potassium antimonal tartrate.	2.3	1.6	2.0	1.2
43. Decomposition products of common nitrates.	2.2	1.5	1.8	1.2
44. Use of bromine to make dyes and tear gases.	2.1	1.7	2.5	1.3
45. Preparation and use of salts of the phosphorus acids.	2.1	1.6	1.8	1.2
46. Properties of allotropic forms of arsenic.	2.1	1.4	2.4	1.3
47. How silicon, used in making steel, is produced from silica.	2.0	1.4	2.3	1.5
48. Use of metallic oxides to color glass.	2.0	1.5	2.0	1.1
49. Use of borax beads in testing for certain metals.	2.0	1.4	1.9	1.6
50. Use of arsenic in making lead shot.	2.0	1.4	2.2	1.5
51. Preparation of sulphur trioxide.	1.8	1.3	1.9	1.2
52. Phosphides and phosphine (poison) used in some naval shells.	1.8	1.3	2.0	1.2
53. Acids of phosphorus.	1.8	1.5	1.5	1.0
54. Preparation of halogen hydrides (HF, HCL, HBr, and HI).	1.7	1.1	1.8	1.2
55. Properties of allotropic forms of phosphorus.	1.7	1.2	1.5	1.2
56. Occurrence and preparation of antimony.	1.7	1.3	1.9	1.2
57. Heat of formation of hydrides and relative activity of the halogens.	1.6	1.1	1.5	1.1
58. Methods of preparation of phosphorus.	1.6	1.2	1.6	1.0

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
VI METALS AND THEIR COMPOUNDS				
1. Reasons for painting.	4.5	4.0	4.4	4.1
2. Numerous uses of copper.	4.3	3.5	3.7	3.2
3. Properties making copper of economic importance.	4.2	3.4	3.0	2.4
4. Sodium hydroxide (carstic soda) and its many uses.	4.1	3.4	3.6	2.7
5. How iron is protected from corrosion.	4.1	3.5	4.1	3.2
6. Uses of lead.	4.1	3.4	4.0	2.9
7. Composition of white wash, plaster, and mortar.	4.0	3.3	3.6	2.7
8. Forms of calcium carbonate (limestone, coquina, marble, calcite, iceland spar, and chalk).	3.9	3.2	3.2	2.1
9. Properties and numerous uses of aluminum.	3.9	3.5	3.2	2.5
10. Danger of poisoning in use of lead pipe for carrying drinking water.	3.9	3.1	4.1	2.9
11. Arsenate of lead (poison) used to kill insects.	3.9	3.3	3.9	3.0
12. Mercuric chloride (corrosive sublimate) a deadly poison and its use for sterilizing surgical instruments and wounds.	3.9	2.9	3.6	2.4
13. Properties and use of silver.	3.9	3.1	3.6	2.9
14. Numerous uses of sodium carbonate.	3.8	3.3	3.3	2.5
15. Uses made of these various forms of calcium carbonate.	3.8	3.1	2.7	1.7
16. Uses of various types of iron and steel.	3.8	3.2	3.8	3.0
17. Lead tetra ethyl in gasoline which prevents automobile engine "knock".	3.8	3.5	4.0	3.7
18. Composition of paints (liquid vehicle, base, pigments, fillers, and thinners).	3.8	3.1	3.5	2.8
19. Why mercury is used in thermometers and barometers.	3.8	2.9	3.6	2.9
20. Mercurous chloride (calomel) used in medicine and danger involved in taking any but pure white tablets.	3.8	2.9	3.4	2.4

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
VI METALS AND THEIR COMPOUNDS (continued)				
21. How the blast furnace works.	3.7	1.8	3.3	1.7
22. Methods of producing steel (Bessemer, open hearth, crucible, and electrical).	3.7	2.3	3.3	2.0
23. Means of annealing, hardening and tempering steel.	3.7	2.4	3.2	2.2
24. Uses of tin.	3.7	3.1	3.9	3.2
25. General methods of metallurgy.	3.6	2.1	2.5	1.4
26. Use of sodium cyanide (poison) as a fumigant and for ridding orchards of parasites, and in the mining of gold.	3.6	2.4	3.4	2.2
27. Explanation of X-rays.	3.6	2.6	3.9	2.5
28. Common properties of zinc.	3.6	2.8	2.7	1.5
29. Use of zinc to make galvanized iron, and electrical devices.	3.6	2.9	3.0	1.9
30. Properties of chromium which make it valuable as a covering for other metals.	3.6	3.2	2.8	1.9
31. Alloys of chromium such as nichrome and cromel used as wire for electric toasters and heaters.	3.6	3.1	3.0	2.2
32. Methods of producing pig, cast, and wrought iron.	3.6	2.0	3.4	1.9
33. Alloy or special types of steel and their uses.	3.6	2.9	3.6	2.5
34. Composition and properties of alloys in common use.	3.6	2.9	3.3	2.4
35. Lead acetate used as a remedy for poison ivy, eczema, and ulcers.	3.6	3.0	3.7	2.5
36. Steps involved in making photographs.	3.6	2.5	3.1	2.4
37. Properties of gold.	3.6	2.7	2.9	1.7
38. Uses of platinum.	3.6	2.7	3.3	1.9
39. Methods of making quicklime, hydrated lime and slaked lime.	3.5	2.8	2.8	2.3

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
VI METALS AND THEIR COMPOUNDS (continued)				
40. Uses of magnesium minerals to make laundry tubs, table tops, electrical switchboards, brick, milk of magnesia, tooth powders, cosmetics, and heat insulators.	3.5	3.1	3.2	2.2
41. Uses of gold.	3.5	3.2	3.4	2.7
42. Properties of radium and uranium.	3.4	2.0	3.0	1.5
43. Formation of plaster of Paris used to make casts, as a plaster for walls, and for calcimining.	3.4	3.0	3.3	2.9
44. Composition and use of lacquers.	3.4	3.0	3.2	3.0
45. Silver sulphide responsible for darkening silver and how it may be removed.	3.4	2.9	3.2	2.8
46. How silver plating is done.	3.3	2.0	3.2	1.8
47. Use of silver nitrate (lunar caustic) for cauterizing wounds and removing abnormal growths.	3.3	2.3	3.2	1.7
48. Properties of certain silver compounds which adapts them to photography.	3.3	2.8	2.7	2.0
49. Properties of potassium and sodium.	3.2	2.0	2.6	1.4
50. Potassium chloride and its use in fertilizers.	3.2	2.7	3.0	2.2
51. Wide distribution of calcium compounds.	3.2	2.2	2.7	1.7
52. Manufacture of tungsten and its use in electrical bulbs and tubes of all kinds.	3.2	2.9	3.2	1.8
53. Occurrence of iron in various ores (hematite, magnetite).	3.2	2.1	1.9	1.3
54. How blue prints are made.	3.2	2.4	3.7	2.3
55. Copper sulphate (blue vitriol), and its uses.	3.1	2.6	2.8	1.7
56. Amalgam used for filling teeth, and for back of cheap mirrors.	3.1	2.5	2.7	2.3
57. Preparation of sodium thiosulphate ("hypo") and its use in photography.	3.0	2.4	2.9	2.2

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
VI METALS AND THEIR COMPOUNDS (continued)				
58. Gypsum (alabaster), and its use in making small statuary, and as land plaster.	3.0	2.3	2.7	2.3
59. Corundum and emery (oxide of aluminum) used for abrasives.	3.0	2.4	2.7	1.9
60. Preparation and use of zinc oxide as a paint pigment, and in rubber vulcanization.	3.0	2.1	2.9	2.2
61. Methods of making white lead used in paints.	3.0	2.1	3.2	2.5
62. Potassium carbonate (potash) made from wood ashes.	2.9	2.1	2.8	2.2
63. Common magnesium minerals (soapstone or talc, harnblend, asbestos, and serpentine).	2.9	1.9	2.9	1.6
64. Ferrous sulphate and its use in making rouge, ink, bluing, and as spray to kill dandelions.	2.9	2.4	2.7	2.1
65. Occurrence and metallurgy of copper.	2.9	1.9	2.7	1.8
66. Use of mercury vapor to conduct electricity and emit light rays such as ultra violet rays.	2.9	2.0	3.2	2.2
67. How mirrors are silvered.	2.9	1.9	3.1	1.6
68. Occurrence and properties of platinum.	2.9	2.1	2.9	1.4
69. The replacement series of metals.	2.8	1.8	2.0	1.2
70. Preparation of zinc.	2.8	1.6	1.8	1.2
71. How iron and steel is tested.	2.8	1.8	3.2	1.8
72. Occurrence, smelting, and purification of lead.	2.8	1.6	2.4	1.6
73. Use of mercuric fulminate in percussion caps and danger involved if struck.	2.8	2.0	3.9	2.3
74. Occurrence and metallurgy of silver.	2.8	1.9	2.6	1.5
75. Occurrence of potassium salts.	2.8	1.9	1.8	1.2
76. Leblanc and Solvay processes for making sodium carbonate.	2.7	1.4	1.7	1.4

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
VI METALS AND THEIR COMPOUNDS (continued)				
77. Use of barium sulphide in making lithopone to replace white lead in paints.	2.6	1.7	2.4	1.7
78. Bauxite and its use in making abrasives and crucibles.	2.6	1.9	2.4	1.6
79. Processes of liberating aluminum from compounds.	2.6	1.7	2.1	1.2
80. Occurrence and use of molybdenum for sparking terminals of spark plugs and other electrical devices.	2.6	2.1	2.7	2.2
81. Occurrence and preparation of tin.	2.6	1.7	2.7	1.5
82. Occurrence and metallurgy of gold.	2.6	1.6	2.5	1.3
83. Occurrence and preparation of mercury.	2.5	1.6	2.5	1.4
84. Use of aluminum hydroxide to absorb dyes, forming lakes.	2.4	1.7	2.1	1.2
85. Use of lead, barium and zinc chromates as yellow pigments for paints.	2.4	2.0	2.5	2.0
86. Alums and their use as mordants.	2.4	1.7	2.1	1.4
87. Zinc sulphate and its use as a mordant and to make lithopone for paints.	2.4	1.9	2.6	2.0
88. Use of silver nitrate for laundering inks.	2.4	1.7	2.7	1.9
89. Strontium nitrate and its use for red flares.	2.3	1.6	1.7	1.2
90. Use of potassium dichromate for making photogravures, and in tanning leather.	2.3	1.6	2.4	2.0
91. Vanadium and its use in making superior quality steel.	2.3	1.6	2.6	1.5
92. Formation of cuprous oxide when testing for sugar with Fehling's solution.	2.3	1.5	1.8	1.1
93. Preparation, and use of sodium peroxide as an oxidizing agent.	2.2	1.9	2.2	1.2
94. How ferrous and ferric salts are formed.	2.2	1.3	1.8	1.4
95. Zinc chloride and its use as fibre for electrical insulation.	2.1	1.6	2.5	2.0

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
VI METALS AND THEIR COMPOUNDS (continued)				
96. Lead chromate, a yellow pigment for paint and a dye. ---	2.1	1.6	2.4	1.7
97. Preparation of aluminum chloride used as catalytic agent to "crack" petroleum molecules. ----------	2.0	1.2	1.8	1.2
98. Tests for ferrous and ferric salts. ----------	2.0	1.3	1.6	1.3
99. Alloys containing cobalt used as cutting instruments. --	2.0	1.4	2.7	1.4
100. How metallic calcium and magnesium are prepared. -------	1.9	1.2	2.0	1.2
101. Use of titanium chloride to produce smoke screens in warfare. ----------	1.9	1.4	2.2	1.2
102. Process of making artificially, and the occurrence of, rubies and sapphires (oxides of aluminum). ----------	1.8	1.3	1.8	1.4
103. Stannic sulphide (mosaic gold) used for gilding. -------	1.8	1.6	2.2	1.8
104. Composition of garnet, micas and turquoise. ----------	1.7	1.2	1.7	1.2
105. Occurrence and preparation of manganese. ----------	1.7	1.2	1.7	1.2
106. Use of molybdenum compounds in dyeing, and as a color in porcelain glazes. ----------	1.7	1.4	2.3	1.8
107. Mond process of preparing metallic nickel. ----------	1.7	1.1	1.7	1.2
108. Sympathetic or invisible ink made from salts of cobalt.	1.7	1.3	2.4	1.3
109. Lead nitrate a good mordant. ----------	1.7	1.3	2.1	1.8
110. Lead sulphide and test for lead ions. ----------	1.7	1.2	1.7	1.2
111. Use of cupric oxide to color porcelain. ----------	1.7	1.2	2.1	1.6
112. Mineral sources of strontium compounds. ----------	1.6	1.1	1.5	1.1
113. Use of rutile (titanium oxide) as white paint base. ----	1.6	1.2	2.2	1.5
114. Use of cadmium sulphide for making artists' yellow paint.	1.5	1.1	1.7	1.3
115. Ammonium molybdate and its use to detect phosphates. ---	1.5	1.2	1.4	1.2
116. Use of stannous chloride as test for mercury. ----------	1.5	1.1	1.7	1.2
117. Amphoteric nature of tin. ----------	1.5	1.1	2.0	1.2
118. Occurrence of titanium in silicates and iron ores. -----	1.2	1.1	1.9	1.3

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
VII HYPOTHESES THEORIES AND LAWS OF CHEMISTRY				
1. Law of conservation of matter.	4.1	2.7	3.2	2.1
2. Law of conservation of energy.	3.9	2.5	3.0	2.2
3. Atomic theory.	3.8	2.1	2.7	1.8
4. Molecular theory .	3.7	2.1	2.7	1.4
5. Law of constant composition, or definite proportions.	3.4	2.1	2.7	1.6
6. Electron theory.	3.3	1.7	2.8	1.7
7. Kinetic theory of gases.	3.2	1.6	2.5	1.6
8. Law of Boyle.	3.0	1.9	2.6	1.5
9. Law of Charles.	2.9	1.8	2.4	1.5
10. General theory of ionization.	2.9	1.8	2.7	1.5
11. Structure of typical atoms according to the electron theory.	2.8	1.4	2.2	1.3
12. Gay Lussac's law of gas volumes.	2.8	1.7	2.3	1.4
13. General Gas Law or formula.	2.8	1.6	2.7	1.9
14. How electrolytes affect the freezing and boiling points of water.	2.8	1.8	2.3	1.4
15. Why some reactions go to completion.	2.8	1.5	2.0	1.2
16. Law of multiple proportions.	2.7	1.6	2.4	1.4
17. Avogadro's hypothesis.	2.7	1.5	2.0	1.4
18. Electrolysis explained by ionization.	2.7	1.3	2.3	1.3
19. Acids, bases and salts considered according to ionic theory.	2.6	1.6	1.7	1.2
20. Metals and non-metals from ionic standpoint.	2.3	1.2	1.9	1.2
21. Chemical equilibrium and reversible reactions.	2.3	1.3	2.0	1.2
22. Law of electro-chemical equivalents.	1.9	1.2	1.9	1.3
23. Mass action law, and common ion effect.	1.8	1.2	1.9	1.1

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
VIII CALCULATIONS OF THE CHEMIST				
1. Simple measurements in the metric system.	4.3	3.1	3.9	2.7
2. Conversion of metric units into English units and vice versa.	3.6	2.8	3.7	2.7
3. How equations are written and balanced.	3.4	2.1	3.3	2.1
4. Changing centigrade readings to Fahrenheit readings and vice versa.	3.4	2.7	3.5	2.6
5. Percentage composition of compounds.	3.0	2.0	2.7	1.6
6. Calculation of the weight of a substance which can be obtained in a chemical change with stated amounts of reacting substances.	2.9	1.7	2.5	1.7
7. Calculation of relative humidity.	2.6	2.0	2.6	1.6
8. Calculation of simplest formula for a compound from its percentage composition.	2.3	1.4	2.6	1.4
9. Calculation of molecular weights from given atomic weights.	2.3	1.7	1.8	1.3
10. Determination of formula by use of valence.	2.3	1.4	2.1	1.4
11. Determination of weight of given volumes of gases when density is known.	2.2	1.4	2.5	1.6
12. Determination of volume of gas when weight of unknown volume and density are given.	2.2	1.4	2.5	1.6
13. Calculations of change of volume or pressure according to Boyle's Law.	2.2	1.2	2.3	1.8
14. Determination of change in volume or temperature according to Law of Charles.	2.2	1.3	2.4	1.6
15. Determination of change in volume, pressure, or temperature according to the general gas law.	2.1	1.3	2.5	1.5

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
VIII CALCULATIONS OF THE CHEMIST (continued)				
16. Meaning and determination of gram atomic and gram molecular weights.	2.1	1.4	2.0	1.6
17. Determination of volume after weight is obtained in the above type of problem.	2.0	1.3	2.2	1.5
18. Determination of the valence from the atomic and equivalent weights.	2.0	1.3	1.5	1.1
19. Problems based on heat of fusion and vaporization.	2.0	1.2	2.0	1.5
20. Calculation of molecular formula of a compound when the molecular weight and simplest formula are known.	1.9	1.4	1.5	1.4
21. Determination of the number of atoms in a molecule by Gay Lussac's law and Avogadro's theory.	1.8	1.1	2.0	1.4
22. Determination of specific heat, and problems based on specific heat.	1.8	1.2	2.0	1.4
23. How to calculate exact or corrected pressure of gases when vapor pressure is a factor.	1.7	1.2	2.4	1.4
24. Vapor density method of determining molecular weights.	1.7	1.1	1.7	1.3
25. Determination of molecular weights when substance is non volatile, but not an acid, base or salt, (based on change of boiling and freezing point of such solutions).	1.5	1.0	1.9	1.4
26. Cannizzaro method of finding atomic weights.	1.5	1.0	1.5	1.2
27. Determination of atomic weights from the equivalent weights.	1.5	1.1	1.5	1.3
28. Accurate determination of atomic weights by analyses of pure substances.	1.5	1.1	2.0	1.4
29. Calculations based upon law of electro-chemical equivalents.	1.5	1.1	1.8	1.5
30. Law of Dulong and Petit or specific heat method of calculating atomic weights.	1.4	1.0	1.7	1.3

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
IX ORGANIC CHEMISTRY				
A. Nature of Organic Chemistry				
1. Complex nature of molecules of organic substances.	3.0	1.8	2.3	1.5
2. Manner in which carbon atoms combine with similar atoms.	2.3	1.3	1.9	1.5
3. Structural formulas and how to construct them.	2.2	1.2	1.7	1.4
4. Un-ionized nature of organic compounds.	2.0	1.4	1.7	1.6
5. Compounds formed by sharing of electrons by carbon atoms.	1.6	1.2	1.9	1.5
B. The Hydrocarbons				
1. Petroleum the common source of hydrocarbons.	3.9	2.8	3.0	2.3
2. Occurrence and formation of petroleum.	3.8	2.7	3.4	2.1
3. Method of fractional distillation of petroleum.	3.6	2.2	2.6	1.5
4. Chloroform, an anesthetic and solvent of fats, and rubber.	3.4	2.3	3.2	2.4
5. Iodoform, a strong disinfectant and antiseptic.	3.3	2.2	3.4	2.6
6. Natural gas as a source of hydrocarbons.	3.2	2.1	2.7	1.8
7. Other sources of hydrocarbons such as coal, oil, shale, ozoderite, and asphalt.	3.2	2.2	3.0	2.1
8. Use of ethylene to ripen fruits, and in illuminating gases.	2.9	1.8	3.1	2.2
9. Methane or paraffin series of hydrocarbons.	2.7	1.7	2.5	1.7
10. Composition and uses of asphalt.	2.7	2.2	3.3	2.6
11. Ethylene and the discovery which revealed it as an excellent anesthetic.	2.7	1.6	2.8	1.5
12. Preparation of acetylene.	2.4	1.9	2.6	1.6

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
B. The Hydrocarbons (continued)				
13. Bergius process of producing hydrocarbons from coal. ---	2.3	1.2	1.8	1.2
14. How it should be stored in acetone. ----------	2.3	1.5	2.2	1.5
15. Isoprene and its use in production of synthetic rubber.	2.2	1.2	2.4	1.5
16. How benzene is made from acetylene. ----------	1.8	1.2	2.1	1.5
C. The Alcohols				
1. Poisonous nature of denatured alcohol. ----------	4.4	3.4	4.2	3.3
2. Dangerous properties of wood, or methyl alcohol (poison)	4.3	3.2	4.0	2.7
3. The alcohol problem and suggestions for its control. ---	4.3	3.9	4.0	3.8
4. Nature and proper uses for medicated alcohol. ----------	4.0	3.5	4.0	3.5
5. Manufacture of sugars from starches in plants. ---------	3.8	2.8	3.2	2.0
6. Common names for ethyl alcohol. ----------	3.7	3.1	3.2	2.6
7. Use of ethyl alcohol for tinctures (as of iodine), in manufacture of other organic compounds, and as a solvent for perfumes and flavors. ----------	3.6	3.1	3.0	2.2
8. Preparation or manufacture by fermentation. ----------	3.6	2.9	2.8	1.9
9. Alcohol content of wines, beer and liquors. ----------	3.6	3.0	4.1	3.2
10. Method of preparation of common alcohols, such as methyl or wood alcohol and ethyl alcohol. ----------	3.4	2.6	3.1	2.3
11. Use of ethyl alcohol to dissolve out compounds found in plants for medicinal purposes. ----------	3.4	2.2	2.7	1.8
12. Use of methanol as a solvent for varnishes and lacquers.	3.3	2.6	3.2	2.4
13. Ethylene glycol and its use as an anti-freeze solution.	3.3	2.8	3.7	3.3
14. Use of glycerine in making explosive glycerol nitrate and as anti-freeze solution. ----------	3.0	2.5	2.7	2.3

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
C. The Alcohols (continued)				
15. "Canned heat", a jelly containing alcohol and calcium acetate.	2.9	2.5	3.7	2.3
16. Properties of glycerine.	2.9	2.3	2.7	2.2
17. Preparation of glycerine from fats as by-product of soap industry.	2.8	2.1	2.6	1.9
18. New German method of making wood alcohol from inorganic substances.	2.7	1.6	2.4	1.5
19. The simpler alkyl groups and their formula.	2.5	1.6	3.0	1.7
20. Relation to paraffins.	2.0	1.1	1.9	1.3
21. Preparation and use of ethylene di-nitrate to replace nitro-glycerine in the manufacture of dynamite.	1.8	1.0	2.1	1.2
D. The Aldehydes				
1. Formaldehyde (formalin), and its use as a preservative and disinfectant.	3.4	2.6	3.4	2.5
2. Injurious effect of formaldehyde on digestive system.	3.3	2.3	3.3	2.3
3. Use in making molding plastics, such as bakelite and redmanol.	2.5	1.8	2.7	1.5
4. Names of common aldehydes.	2.4	1.7	2.2	1.6
5. Use to produce alcohols by synthesis.	1.9	1.1	1.8	1.3
6. Preparation by oxidation of alcohols.	1.8	1.2	1.8	1.5
7. Chemical relation to alcohols.	1.8	1.2	1.9	1.3
8. Equations for such reactions.	1.5	1.2	1.5	1.3

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
E. Organic Acids				
1. Use of oxalic acid to remove fresh rust and ink stains from cloth.	3.5	2.9	2.6	2.7
2. Why insect bites are treated with bases.	3.2	2.5	3.2	2.6
3. Vinegar is dilute acetic acid with color due to other substances.	3.2	2.6	3.0	2.3
4. Poisonous nature of oxalic acid.	3.2	1.9	3.3	2.0
5. Citric acid and its presence in citrous fruits.	3.2	2.4	3.0	2.7
6. Slow and rapid processes of preparing vinegar by fermentation of sugars in cider.	3.0	2.3	3.2	3.0
7. Preparation of acetic acid.	2.8	1.8	2.6	1.9
8. Presence of tartaric acid or its salts in some fruits.	2.7	2.0	2.7	2.2
9. Malic acid in unripe apples, currants, rhubarb, and cherries.	2.7	2.2	3.2	2.7
10. Organic acids react with bases to form salts.	2.5	1.7	2.0	1.3
11. Presence of butyric acid in rancid butter, and perspiration.	2.5	1.7	2.7	2.0
12. Its use in making dyes, and brass polish.	2.5	1.8	2.4	2.0
13. Use of formic acid in making dyes and as a reducing agent.	2.3	1.4	2.4	1.7
14. Preparation of perfumes from evil smelling butyric acid.	2.2	1.4	2.2	1.3
15. Use of acetic acid in preparation of esters.	2.1	1.3	2.6	1.6
16. Preparation of oxalic acid from sawdust and sodium hydroxide.	1.9	1.2	2.2	1.4
17. Carboxyl or acid group present in such compounds and its formula.	1.7	1.0	1.5	1.2

Table 3.(continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
E. Organic Acids (continued)				
18. Salts of oxalic acid found in plants.	1.7	1.2	2.1	1.5
19. Preparation from corresponding aldehyde.	1.6	1.1	1.6	1.3
20. Methods of preparing formic acid.	1.6	1.1	1.9	1.3
F. Esters				
1. General considerations concerning the choice and use of lubricants.	3.6	3.5	3.9	3.7
2. Composition of butter and oleomargarine.	3.5	3.0	3.9	3.4
3. Properties and uses of mineral oils.	3.4	3.2	3.7	3.2
4. Linseed oil and why it is used in paints.	3.4	2.7	4.0	3.3
5. Common mineral oils prepared from petroleum.	3.2	2.8	3.3	3.2
6. Properties and uses of greases.	3.2	2.9	3.7	3.4
7. Medicinal soap a mixture of soap and antiseptic.	3.2	2.6	3.3	2.5
8. Common oils and fats procured from animals.	3.1	2.8	3.6	2.6
9. Soaps of most metals insoluble as in case of calcium and magnesium found in hard water.	3.0	2.3	2.8	2.2
10. Common fats are stearin, palmitin and olein.	2.9	2.1	2.6	2.0
11. Common oils and fats procured from plants.	2.9	2.6	3.2	2.3
12. Tests applied to oils such as specific gravity, viscosity, cold test, flash tests, fire tests and gumming tests.	2.8	2.0	2.9	2.2
13. Why some soap floats.	2.8	2.4	3.2	2.4
14. Odors of many flowers and fruit flavors due to presence of sweet smelling ethereal salts.	2.7	2.0	2.8	2.2
15. Manufacture of waxes.	2.5	1.7	3.2	2.2

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
F. Esters (continued)				
16. Odors of common esters.	2.4	1.8	2.7	1.8
17. Production by reaction of an acid and an alcohol.	2.3	1.4	1.9	1.5
18. Hydrolysis of fats to produce glycerine.	2.3	1.5	2.5	1.6
19. Readily hydrolized to form acid and alcohol.	1.6	1.0	1.6	1.5
G. Hydrocarbons and derivatives from Coal				
1. Use of carbolic acid as an antiseptic and for disinfectant purposes. (poison)	4.0	3.1	3.7	3.0
2. Properties of carbolic acid (phenol).	3.5	2.5	2.9	2.0
3. Properties and precautions to be observed in use of tri-nitro toluene (T.N.T.)	3.4	1.8	3.6	2.2
4. Explanation of distillation of coal.	3.3	2.2	3.3	2.1
5. Use of salicylic acid and its derivatives as antiseptic, remedy for rhuematism and in making aspirin.	3.2	2.4	3.3	2.7
6. Use of phenacetin as remedy for headache and neuralgia.	2.9	2.4	3.2	2.7
7. Cresols (cresylic acids) used as disinfectants in drains.	2.9	2.5	3.1	2.8
8. Use of hydrocarbon derivatives with distinct odors such as oil of bitter almonds, oil of cloves and oil of wintergreen.	2.8	2.3	3.1	2.2
9. Production of aniline dyes.	2.7	1.8	2.5	2.1
10. Properties and dangers involved in use of tri-nitro phenol (picric acid).	2.6	1.5	2.8	1.7
11. Phenols are hydroxides of benzene.	2.1	1.2	1.8	1.3
12. Properties which indicate difference from alcohols.	2.1	1.5	2.3	1.5

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
G. Hydrocarbons and derivatives from Coal (continued)				
13. Use of phenol in preparation of salicylic and picric acids and phenacetin.	2.1	1.5	1.9	1.5
14. Napthalene used as antiseptic and in the preparation of azo-dyes.	2.0	1.3	2.4	1.6
15. Benzene and its homologues, toluene and xylene.	1.9	1.4	2.1	1.5
16. Nitration or the process of forming nitro compounds of the aromatic hydrocarbons.	1.8	1.4	1.7	1.2
17. Preparation of amino derivatives of benzene hydrocarbons.	1.6	1.2	1.8	1.5
18. Composition of aromatic aldehydes.	1.6	1.1	1.7	1.2
19. Composition of aromatic acids.	1.6	1.1	1.7	1.2
20. Structure of benzene molecule.	1.5	1.1	1.8	1.3
21. Ortho, meta and para compounds of benzene.	1.4	1.1	1.8	1.2
22. Resorcinol used in preparation of the dyes eosin and fluorescein.	1.4	1.3	1.9	1.2
23. Composition of aromatic aldehydes.	1.4	1.3	1.7	1.3
24. Use of anthracene to make dyes especially alizarin.	1.4	1.2	1.7	1.5
H. Products from Plants and Animals				
1. Classes of compounds found in plant and animal tissue (fats, carbohydrates and protein).	4.5	3.5	3.7	2.7
2. Cellulose the chief constituent of wood, linen, paper and cotton.	3.9	2.8	3.6	2.6
3. Relation of glucose to the disease called diabetes.	3.8	2.9	3.9	2.7
4. Manufacture of starch in plants.	3.8	2.7	3.4	2.0
5. Sources of starch.	3.7	2.7	3.7	2.7
6. Process of photosynthesis.	3.6	2.5	2.7	2.1

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
H. Products from Plants and Animals (continued)				
7. Use of collodion ("new skin") for cuts, and in making artificial silk.	3.6	2.9	3.6	2.7
8. Composition of these compounds.	3.6	2.6	2.9	2.1
9. Chemical process responsible for souring milk.	3.5	3.1	3.1	2.7
10. Numerous uses of cellulose acetate, as on airplane wings, electrical insulators, and artificial silk.	3.5	2.5	3.2	2.2
11. Process of extraction and refining of sugar.	3.4	2.4	3.3	2.2
12. Effect of process of vulcanization.	3.4	2.8	3.8	2.7
13. How fructose aids persons with diabetes.	3.3	2.4	3.3	2.4
14. Properties which make cellulose lacquers suitable for finishing automobiles.	3.3	2.6	3.2	2.0
15. Natural source of glucose (flowers, fruit, sap, and blood).	3.2	2.5	2.8	2.1
16. Test for starches with iodine.	3.2	2.6	2.6	1.7
17. Substances and method used in vulcanization.	3.2	2.4	3.2	2.2
18. Preparation of glucose, dextrose or grape sugar.	3.1	2.0	2.8	2.0
19. Properties of cellulose acetate.	3.1	2.3	2.5	1.7
20. Preparation of cellulose nitrates used in explosives, plastics, artificial silk, and rayon.	3.1	2.4	3.2	2.4
21. Caramel, used in confectionery as flavoring and coloring matter.	3.0	2.4	2.9	2.4
22. Common gums and their uses.	3.0	2.5	3.7	2.5
23. Occurrence of sucrose or cane sugar plants.	2.9	2.3	2.9	2.0
24. Composition and use of explosives such as gun cotton, blasting gelatin, smokeless powder, cordite, and collodion.	2.9	2.1	3.2	2.0
25. Origin and early history of rubber industry.	2.9	2.0	3.2	1.5
26. Use of dextrin (British gum) as an adhesive.	2.8	2.3	2.8	1.7

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
H. Products from Plants and Animals (continued)				
27. Occurrence and function of glycogen (animal starch) in the body.	2.8	1.9	2.8	1.8
28. Advantage of artificial leather made with collodion, over real leather.	2.8	2.5	3.0	2.2
29. Manufacture and properties of celluloid.	2.8	2.5	3.3	2.6
30. Decomposition of starch to dextrin.	2.7	1.7	2.5	1.6
31. How cellulose lacquers are prepared.	2.7	2.1	2.5	1.6
32. Source of lactose in milk of all mammals.	2.5	1.8	2.6	1.9
33. Formation of maltose from starch by the enzyme, diastase	2.5	1.9	2.5	1.7
34. Formula and properties of lactose or milk sugar.	2.4	1.6	2.3	1.8
35. Classes of carbohydrates (mono-saccharides, di-saccharides and poly-saccharides).	2.3	1.7	2.3	1.8
36. Method of coloring celluloid.	2.3	1.7	2.6	1.3
37. Use of plasticizers to prevent breaking and chipping in lacquers.	2.3	1.9	2.6	2.0
38. Formation of invert sugar, a component of honey and sweet fruits.	2.2	1.6	2.6	1.9
39. Properties and formula for maltose or malt sugar.	2.2	1.7	2.5	1.9
40. General properties of mono-saccharides.	2.1	1.4	2.0	1.4
41. Formula and properties of di-saccharides.	1.9	1.4	2.2	1.3
42. Formation of nitro-starch, an explosive.	1.8	1.3	2.2	1.0
43. Difficulty of determining formula for poly-saccharides.	1.4	1.2	1.7	1.2

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
X CHEMISTRY OF SOILS FOODS AND BODY PROCESSES				
1. Minerals required by the body.	4.7	3.8	4.3	3.8
2. Function of water in the body.	4.7	4.2	4.2	3.7
3. Common poisons.	4.7	3.9	4.5	3.9
4. Places and substances in which they are apt to be found.	4.7	3.8	4.4	3.6
5. Function of the oxygen inhaled.	4.6	4.1	4.2	3.5
6. How uncleanliness may cause contamination of foods.	4.5	4.4	4.5	3.7
7. Antidotes for various poisons.	4.5	3.7	4.6	3.6
8. Requirements for plant life.	4.4	3.6	4.2	3.8
9. Classes of compounds used as foods (proteins, carbohydrates, and fats).	4.4	3.9	3.7	3.2
10. Foods which will supply minerals for the body.	4.4	4.3	4.2	3.6
11. General considerations on selection of diet.	4.4	4.1	4.4	4.0
12. Constituents of milk.	4.4	3.8	4.2	3.6
13. Function of minerals required by the body.	4.3	3.4	4.0	3.1
14. Purposes of cooking foods.	4.3	4.3	4.0	3.8
15. Foods now being sold containing adulterants.	4.3	3.7	4.1	3.2
16. Process of pasteurization of milk.	4.3	3.8	4.2	3.3
17. Harmful effects of deficiency or excess of vitamins (cause of scurvy, rickets, beri-beri, pellagra and xerophthalmia).	4.2	3.3	4.5	3.9
18. Kinds and composition of fertilizers.	4.1	3.3	3.8	3.6
19. How soil supplies minerals to plants.	4.1	2.9	3.7	3.3
20. How soil supplies nitrogen to plants.	4.1	3.0	3.7	3.0
21. How soil supplies moisture to plants.	4.1	3.2	3.8	3.2
22. How oxygen and carbon dioxide are supplied.	4.1	2.9	3.6	3.3
23. Meaning, kinds, and function of vitamins.	4.1	3.5	4.3	4.0
24. Vitamins found in common foods.	4.1	3.8	4.4	3.7

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
X CHEMISTRY OF SOILS FOODS AND BODY PROCESSES (continued)				
25. Chemistry of digestion and assimilation.	4.1	3.5	4.1	3.6
26. Danger of destroying vitamins by cooking and throwing away skins of potatoes and some fruits.	4.1	4.0	4.2	3.7
27. Methods of prevention of putrefaction, based on prevention of growth of yeasts, molds, and bacteria.	4.1	3.8	4.2	3.5
28. Refrigeration and its preservative effect.	4.1	3.8	4.3	3.7
29. Sterilization and its effect as a preservative.	4.1	4.0	4.2	3.4
30. Nature and formation of soils.	4.0	3.1	3.8	3.1
31. Causes of putrefaction of food (molds, yeasts and bacteria).	4.0	3.8	4.1	3.3
32. Effect on food of molds and yeasts, particularly the formation of ptomaines (food poisons).	4.0	3.5	4.3	3.4
33. Disinfectants and antiseptics used as food preservatives.	4.0	3.6	4.2	3.2
34. Common adulterants and how they may be detected.	4.0	3.3	4.2	3.5
35. When to use various types of fertilizers.	3.9	3.3	4.0	3.4
36. How molds, yeasts and bacteria reach food.	3.9	3.6	4.2	3.2
37. Harmful effects and dangers involved in use of food preservatives.	3.9	3.6	4.4	3.0
38. What remains to be done in the way of control of use of preservatives.	3.9	3.1	3.4	2.4
39. Work of chemists in providing good safe containers for preserving and transporting foods.	3.9	3.1	4.2	3.1
40. Purpose and means of cultivation.	3.8	3.3	4.2	3.6
41. Function of carbohydrates in the body.	3.8	3.1	3.6	2.7
42. Function of fats in the body.	3.8	3.1	3.6	2.7
43. Function of proteins in the body.	3.8	3.1	3.7	2.8

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
X CHEMISTRY OF SOILS FOODS AND BODY PROCESSES (continued)				
44. Symptoms of such diseases.	3.8	3.0	4.3	3.6
45. Work and control of microorganisms (bacteria) in soil.	3.7	2.5	3.7	3.0
46. Effect of temperature, humidity, light and ultra violet rays on plant life.	3.7	3.1	3.5	3.1
47. Common insect pests which destroy crops.	3.7	3.3	4.2	3.7
48. How the government controls the use of preservatives.	3.7	3.2	3.9	2.4
49. How preservatives in food may be detected.	3.7	3.2	4.0	3.0
50. Examples of fermentation in home and on farm.	3.7	3.3	3.7	3.1
51. Kinds of soil.	3.6	3.0	4.1	3.1
52. Composition of stomach and contact insecticides used to destroy pests.	3.6	2.9	3.7	3.0
53. Classes of proteins and why the diet should contain some of each.	3.6	3.1	3.8	3.2
54. Changes in fats due to cooking.	3.6	3.2	3.7	3.1
55. How drying foods helps preserve them.	3.6	3.1	4.2	3.1
56. Harmful ingredients of some commercial fly sprays and their effects.	3.6	2.7	3.9	3.1
57. How these insecticides may be made and used.	3.5	3.2	3.9	3.4
58. Changes in proteins due to cooking.	3.4	3.1	4.1	2.8
59. How to make a cheap effective fly spray.	3.4	3.1	3.7	3.2
60. Injurious effect on digestive system of crolein found in hot fat.	3.3	2.9	3.5	2.8
61. How condensed milk and milk powders are made.	3.3	2.5	3.7	2.8
62. Average amount of heat liberated by carbohydrates, proteins and fats.	3.2	2.6	3.5	2.9
63. Harmful flavoring matter and how to detect it.	3.2	2.5	4.0	2.9

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
X CHEMISTRY OF SOILS FOODS AND BODY PROCESSES (continued)				
64. Chemical composition of plants.	3.1	2.1	3.3	2.5
65. Energy requirements of the body expressed in calories.	3.1	2.7	3.2	2.8
66. Meaning and function of hormones in the body.	3.1	2.4	3.5	2.6
67. Use of adrenaline in medicine and surgery.	3.1	2.1	3.7	2.2
68. Glands that produce hormones.	3.0	2.3	3.4	2.5
69. Method of measuring energy content of foods in calories.	3.0	2.3	3.7	3.1
70. Diseases which result from excess or deficiency of hormones.	2.9	2.1	3.4	2.2
71. Changes in starches due to cooking.	2.9	3.2	3.8	3.1
72. Flavors and how they are obtained from plants.	2.9	2.0	3.5	2.4
73. Proper percentage composition of jellies and how to detect adulteration.	2.7	2.3	3.7	2.9
74. Synthetic flavors and how they are manufactured.	2.5	1.8	3.3	2.2
75. Pigments which give color to the various parts of the plant.	2.4	1.7	2.7	1.9
76. The hydrolysis of proteins into amino-acids.	2.1	1.6	2.2	1.8
XI CHEMISTRY OF TEXTILES AND CLEANSING				
1. How soap is made.	4.1	2.9	3.7	2.5
2. Kinds of stains and how they may be removed.	4.1	4.1	4.2	3.6
3. Common bleaching agents and how used.	3.9	3.1	3.7	3.2
4. How soap cleans.	3.9	3.4	3.9	3.1
5. Impurities commonly present in soaps and their dangerous effects.	3.9	3.5	3.7	2.9
6. Composition of common washing powders and how they clean.	3.9	3.6	3.8	3.1

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
XI CHEMISTRY OF TEXTILES AND CLEANSING (continued)				
7. How to analyze labels and advertisements.	3.8	3.4	3.7	3.2
8. Types and sources of textiles such as animal or protein, plant or cellulose, and synthetic.	3.7	3.1	3.2	2.8
9. Antiseptic dressings.	3.7	3.2	4.0	3.4
10. Effect of bleaching agents on textiles.	3.7	2.9	3.6	2.7
11. Analysis of claims made in advertisements for various kinds.	3.7	3.4	4.0	3.2
12. Description of the method of dry cleaning.	3.6	3.3	3.7	3.0
13. Misleading labels such as "part wool", and "pre-shrunk".	3.5	3.4	4.0	3.4
14. General properties of each including effect of water, acids, and alkalies on them.	3.4	3.3	3.3	2.4
15. Tests for textile fibres.	3.4	2.7	3.3	2.6
16. Fastness of dyes against light, cleaning, and perspiration.	3.3	2.7	3.5	3.0
17. Artificial silks (chardonnet, viscose) and their properties.	3.2	2.7	2.8	2.3
18. Relation of kind of fibre and method of weaving to wearing value.	3.2	2.7	3.3	2.7
19. How we may test for fastness of dyes.	3.2	2.4	3.6	3.1
20. Bluing composition and its work in cleansing.	3.2	2.8	3.6	2.9
21. How synthetic fibres are made.	3.1	2.4	3.2	2.2
22. Mercerized cotton and how it is made.	3.0	2.4	3.1	2.1
23. Methods of waterproofing textiles.	2.9	2.3	3.0	2.1
24. Advantages over common cotton cloth.	2.9	2.6	3.1	2.4
25. Abuse in weighting silks and how to detect it.	2.8	2.3	3.0	2.2

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Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
XI CHEMISTRY OF TEXTILES AND CLEANSING (continued)				
26. Stiffening and softening substances used.	2.6	2.1	2.8	2.2
27. Sources of natural dyes such as indigo, madder, Tyrian purple, Kermes, cochineal and logwood.	2.6	1.8	3.2	2.3
28. Distinction between direct colors, mordant colors and vat dyes.	2.6	2.0	2.6	1.8
29. How and why degumming and weighting process are applied.	2.5	1.8	2.7	2.0
30. Preparation of synthetic dyes from coal tar and Perkins mauve.	2.4	1.8	2.7	1.9
XII THE CHEMISTRY OF MEDICINES AND DRUG STORE PRODUCTS				
A. Drugs				
1. Dangers involved in the use of drugs.	4.5	3.5	4.5	3.1
2. Characteristics and effects of drugs in common use such as morphine, opium, cocaine, novocaine, quinine and caffeine.	4.3	3.5	4.5	3.1
3. Common, well-advertised patent medicines which contain harmful ingredients.	4.3	3.6	4.2	3.3
4. Characteristics and effect on the body of drug substances found in plants.	4.1	3.2	3.7	2.3
5. How and when they may be of benefit to a person.	4.0	3.3	4.2	2.9
6. Deficiencies of Federal Drug Act.	3.8	3.1	3.6	2.8
7. How to detect presence of them.	3.7	3.1	4.1	3.2
8. Occurrence of these substances in plants.	3.1	2.1	3.1	1.8

Table 3 (continued)

TOPICS AND SUB TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
B. Medicines				
1. Directions for proper use and effects of common medicines.	3.2	2.8	3.7	2.9
2. Chemical composition of medicines used in treatment of common ailments such as goitre and diseases of thyroid gland, hookworm, malaria, sleeping sickness, diabetes, cancer, and leprosy.	2.9	2.4	3.6	2.7
C. Synthetic Medicines				
1. Some common synthetic medicines.	3.3	2.5	3.4	2.7
2. Steps followed by the chemist from the remedy of nature to a pure synthetic remedy or its equivalent.	2.7	1.7	3.3	2.2
D. Laxatives				
1. Impurities and harmful constituents and their effects on the body.	4.3	3.9	4.5	3.2
2. Dangers involved in their use.	4.3	3.9	4.6	3.4
3. Well advertised, but harmful laxatives.	4.3	3.9	4.5	3.6
4. Work required of such substances.	4.2	3.6	4.4	4.0
5. Essential constituents of common ones.	3.9	3.5	4.2	3.2
E. Antiseptics				
1. Value when properly used.	4.5	4.4	4.5	4.0
2. Composition and proper use of common antiseptics such as Dakin's solution, zonite, iodine, mercurochrome, carbolic acid, listerine, and pepsodent.	4.4	4.3	4.4	4.1
3. Limitations of common antiseptics.	4.2	3.9	4.3	3.5

Table 3 (continued)

TOPICS AND SUB-TOPICS	Ratings of Group 1		Ratings of Group 2	
	I	F	I	F
F. Disinfectants				
1. The composition, and proper method for use, of common disinfectants.	4.7	4.4	4.3	3.8
2. Requirements of a good disinfectant.	4.6	4.1	4.3	3.8
3. Natural disinfectants such as sun, air, charcoal.	4.5	4.3	4.4	4.1
4. Tests for disinfection such as innoculation, and culture experiments.	3.3	2.5	3.6	2.8
G. Fumigants				
1. Work done by them.	3.8	3.0	4.3	3.5
2. Composition, and directions for use of common ones.	3.7	3.1	4.3	3.2
H. Deodorants				
1. Common deodorants and how to use them.	4.0	3.6	4.3	3.4
2. What may be expected of them.	3.7	3.3	4.4	3.4
I. Inhalants				
1. Values of common inhalants.	3.8	3.2	4.0	3.2
2. False claims for them.	3.7	3.3	3.9	3.0
3. Common components and effects of these.	3.6	3.2	4.1	3.4
J. Mouthwashes, Toothpastes, and Talcum Powder				
1. Work done by such substances.	4.6	4.4	4.3	4.2
2. Harmful ingredients of some brands.	4.3	3.6	4.0	3.5
3. False claims made for them in advertisements.	4.2	4.0	4.1	3.8
4. Composition of common ones.	3.8	3.3	3.9	3.3

CHAPTER III

FINDINGS AND CONCLUSIONS

Limitations of Conclusions

The possibilities for interpretation and use of the results of this research are extensive and quite beyond the scope of this thesis. We shall attempt only to point out certain uses which might be made of the ratings, how they may be used for such purposes, and certain factors which must be taken into account when they are used.

Suggested Uses for Ratings

These ratings may be used by chemistry teachers as a better-than-empirical basis for the selection of subject matter for a course in chemistry of great practical, everyday value to the pupils.

This does not mean that the ratings should be the only criteria used in making the selection. Factors such as time and equipment available, type of community, intelligence and achievements of students, and difficulty of learning certain topics, must be considered .

The data should also be a valuable aid to those teachers who wish to revise the course which they are using at the present time. The list of topics is large enough so that certain valuable additions should be suggested to them.

Certain topics, which they have been spending considerable time on, may be suggested to have little value from the practical everyday standpoint. Some sense of satisfaction should come to those teachers who find that the course which they have organized and put to use, contains the topics which many persons qualified to judge, consider to be useful and of great importance to the average person.

Since a survey of the textbooks in this field, reveals so few that are suitable for the purpose, the results might be used as a basis for the preparation of a text for such classes. The subject matter could be selected in a more scientific manner, that is, on a basis of the average opinion of many well qualified judges, rather than on the mere opinion of one person, which may be influenced by so many factors. Such a textbook, carefully prepared and written, would be a valuable tool for the teacher of chemistry today. It would also be a very useful addition to the library of the intelligent laymen who wish to know more about their surroundings.

Technique for Use of Ratings

It would not be advisable to set down any given rule for the selection of topics from the table of ratings for the following reasons:

1. Group 1 and group 2 do not at all times agree on the importance of any single topic, as for

example on topic number 3 on page 19, regarding the use of carbon dioxide in baking foods. Group 1 rated it 4.0 and group 2 gave it a value of 2.9. Neither do the raters agree at all times on the frequency with which the person will have some use for the fact. An example of this may be found in topic number 8 on page 16 entitled, "How the chemist solves his problems by inductive and deductive thinking." Group 1 rated it 3.1 while group 2 gave it a value of only 2.1.

2. Facts which the raters consider very important to know about, are sometimes used seldom or not at all, as for example in item number 6 on page 19 entitled, "Methods of preparing oxygen."
3. Teachers of chemistry have a tendency to rate somewhat higher those topics which are dealt with in college-preparatory courses, and with which they are thoroughly familiar. This may be seen on some of the rating lists submitted.
4. The laymen who rated the topics had a tendency to rate many topics low because of their lack of knowledge of the terms used, or their failure to realize the full significance and utility value of some of the topics. Workers in one occupation often fail to realize the knowledge required by

workers in another occupation. This may account for other low ratings of some topics.

The following is a list of suggestions for the selection of topics for the course from the average ratings as given in Table 3.

1. All topics which are rated above the mean for "importance of knowing," by either group of judges, should be included in the course. This would give us 415 topics which can easily be selected from Table 3. This statement is made because of the fact, that although a person may not use the information very often, it may be of vital importance for him to know it when an occasion to use it arises.
2. Any topic rated above the mean for "frequency of use," by either group of judges, should be included in a practical course, because, any fact which a person may use frequently should be an asset to him in his daily life. This would not add many topics to the list, however, since those which rate above the mean for "frequency of use," are rated in most cases above the mean for "importance of knowing."
3. If more topics are desired for the course they may be selected from successively lower ratings

because they are justified from the standpoint of other criteria, such as:

a) They may be necessary for introductory purposes. The topics listed under, "History" on page 15 of Table 3 would come in this class.

b) They may be required for the explanation of other topics of greater importance and frequency of use, such as topic number 14 on page 35, namely, "How electrolytes affect the freezing and boiling points of water." This information would be necessary to explain why salt is used in freezing ice cream.

c) They may have a direct relation to the chief industry of the community. If a soap making factory employed many people of a community, then we should teach something about fats such as stearin, olein and palmitin which are used in its manufacture. This would bring into the course topic number 10 on page 42 which would otherwise be omitted.

d) They may be of a very interesting nature to young students and therefore be

included to develop interest in the science.

e) Some topics may be omitted because of their difficult nature, as for example, "Structure of typical atoms according to the electron theory." This will be found on page 35 of Table 3.

Some General Observations

In conclusion, a summary of the type of chemistry topics which the raters have indicated should have a prominent place in a practical course in chemistry will be given.

Nearly all of the chemical facts which were listed relating to soils, foods, and body processes were rated high. The same may be said of topics about textiles, cleansing, medicines and drug-store products. Topics listed under the headings of water, fire, acids, bases, and salts were for the most part rated somewhat above average. All of these should be included in the course.

Non-metals and their compounds were, in most cases, given ratings below the average. This would indicate that little time should be spent on them.

It would seem that the calculations used by the chemist have little place in a practical course in chemistry. Those which are used in connection with equations, were the only

ones rated of any great value.

In organic chemistry only facts relating to such common products as petroleum, lubricants, oils, cellulose, sugars, starches, and rubber were indicated to have value in a person's everyday life.

The chemistry related to the common metals such as iron, lead, tin, copper, and zinc received the higher ratings. In general, compounds of these metals, and the other metals and their compounds, were considered to be of little importance.

APPENDIX

Books Used in Preparation of Rating-list

Bailey, Edgar H., Textbook of Sanitary and Applied Chemistry, Macmillan Co., Boston, 1906.
This book contains many experiments related to air and food.

Beery, Pauline G., Stuff, Appleton Co., New York, 1930, pp. xiii,504.
A story of materials in the service of man, written for the layman.

Bennett, Harry, Practical Everyday Chemistry, Garden City Publishing Co., New York, 1934, pp. xv,305.
The title of this book is misleading. It gives directions for making hundreds of commonly used products.

Black, Newton H., and James B. Conant, New Practical Chemistry, Macmillan Co., Boston, 1936, pp. x,621.
A new text for secondary schools.

Butler, J., The Chemical Elements and Their Compounds, Macmillan Co., Boston, 1930, pp. xi,205
An advanced textbook adapted for college use.

Cameron, Donald A., Chemical Warfare, International Pamphlets, New York, 1930, pp. 31.
A good account of the composition and uses of gases used in warfare.

Chamberlain, Joseph S., Chemistry in Agriculture, Chemical Foundation, New York, 1926, pp. xi,384.
A treatment of the chemical processes involved in plant growth.

Conant, James B., The Chemistry of Organic Compounds, Macmillan Co., New York, 1934, pp. x,623.
A one year course in organic chemistry.

Dinsmore, Ernest L., Chemistry for Secondary Schools, Ambrose Co., New York, 1925, pp. viii,574.
A text based on the belief that the training required for college is the same as that required for daily life.

Foster, William, The Elements of Chemistry, Van Nostrand Co., New York, 1932, pp. xx,653.
A well organized text suitable for the beginner.

Fuller, Robert W., R. Brownlee and D. Baker, First Principles of Physics, Allyn Bacon Co., New York, 1933, pp. viii, 799.

Glasstone, Samuel, Chemistry in Daily Life, Methuen Co., London, 1929, pp. vi,250.
Contains much information on synthetic foods, medicines and dyes.

Greer, Carlotta, and J. Cora Bennett, Chemistry, Allyn and Bacon Co., Boston, 1926, pp. xvii,844.
A text arranged on a question and answer basis suitable for use in a practical course in chemistry.

Holmes, Harry N., General Chemistry, Macmillan Co., New York 1930, pp. x,654.

Holmes, Harry N., Out of the Test Tube, Long and Smith Co., New York, 1934, pp. x,373.
A book for the intelligent but non-technical person who wishes to understand the research and work of the chemists of today.

Holmes, Harry N., Introductory College Chemistry, Macmillan Co., Boston, 1936, pp. xiii,550.

Howard, Russell S., Units In Chemistry, Henry Holt Co., New York, 1934, pp. lxviii,746.
A new high school text organized in units very different from most texts for this purpose.

Howe, Harrison E., and Francis M. Turner, Chemistry and the Home, Scribner's Sons, New York, 1927, pp. x,355.
Chemistry and its relation to articles used in the home.

Hunter, George W., and W. Whitman, Problems in General Science, American Book Co., New York, 1930, pp. xii,688.
This text contains many applications of chemical facts to everyday life.

Kallett, Arthur, Counterfeit, Vanguard Press, New York, 1935, pp. 7,95.
An account of what the consumer's money actually buys.

Kallett, Arthur and F. Schlink, 100,000,000 Guinea Pigs, Vanguard Press, New York, 1933, pp. xi,312.
Dangers in use of everyday foods, drugs, and cosmetics.

Lynde, Carleton J., Everyday Physics, Macmillan Co., Boston, 1930, pp. xiii,577.
A simple text for use in a practical physics course.

MacLeod, Annie L., Textbook of Chemistry for Nurses and Students of Home Economics, McGraw-Hill Co., New York, 1928, pp. xiii,241.
This text contains a clear, simple explanation of the atomic and electron theories.

MacLeod, Annie L., and E. Nason, Chemistry and Cookery, McGraw-Hill Co., New York, 1930, pp. xii,545.

Naylor, Nellie M., and Amy LeVesconte, Introductory Chemistry with Household Applications, Century Co., New York, 1933, pp. x,367.

Newell, Lyman C., Practical Chemistry, Heath Co., Boston, 1929, pp. viii,707.
This book contains full directions for 237 laboratory experiments.

Richmond, Henry D., Dairy Chemistry, Griffin Co., London, 1914.
An intensive treatment of all aspects of dairying.

Rogers, Allen, Industrial Chemistry, Van Nostrand Co., New York, 1931, 2 vol.
An advanced industrial chemistry. The first volume deals with organic chemistry and the second treats the inorganic aspect of chemistry.

Slossons, Edwin E., Creative Chemistry, Century Co., New York, 1919, pp. ix,311.
A description of recent achievements in the chemical industries.

Schlink, Frederick J., Eat, Drink and Be Wary, Covici-Friede Co., New York, 1935, pp. xi,335.
An account of the problems confronting the people in the matter of diet and food adulteration.

Thorpe, T., Outlines of Industrial Chemistry, Macmillan Co., New York, 1916, pp. xxv,655.

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